Sipho Buthelezi, Halliru Ibrahim, Muhammad D. Bala* and Holger B. Friedrich

Crystal structure of 4-*tert*-butyl-2-*N*-(2-pyridylmethyl)aminophenol, C₁₆H₂₀N₂O

Table 1: Data collection and handling.

Crystal:	Yellow needle
Size:	0.18 × 0.14 × 0.12 mm
Wavelength:	Mo K α radiation (0.71073 Å)
μ :	0.07 mm ⁻¹
Diffractometer, scan mode:	Bruker APEX-II, φ and ω
$\theta_{\max}$, completeness:	26.0°, 99%
$N(hkl)_{\text{measured}}$, $N(hkl)_{\text{unique}}$, R_{int} :	17,539, 5603, 0.023
Criterion for I_{obs} , $N(hkl)_{\text{gt}}$:	$I_{\text{obs}} > 2 \sigma(I_{\text{obs}})$, 4178
$N(\text{param})_{\text{refined}}$:	351
Programs:	Bruker [1], SHELX [2, 3], Olex2 [4]

Source of material

The title compound was prepared by the condensation of equimolar amounts of 2-amino-4-*tert*-butylphenol (3 g, 18.16 mmol) and 2-pyridinecarboxaldehyde (1.72 mL, 18.16 mmol). This was achieved by stirring the two reagents in refluxing methanol (50 mL) for 2 h. Excess NaBH₄ (1.37 g; 36.32 mmol, 2 M equivalents) was then slowly added to the reaction content at 0 °C and the resulting mixture stirred under reflux and inert condition for 3 h. All volatiles were removed, and the brown residue obtained was dissolved in distilled water to destroy any unreacted NaBH₄. The pH of the mixture was adjusted to seven by the gentle addition of glacial acetic acid, and the organics were extracted with DCM (3 × 50 mL). The combined organic extracts were dried with anhydrous magnesium sulphate and filtered. The filtrate was then concentrated using a rotavapor to yield a pale brown gummy product. Subsequent precipitation/washing with a mixture of diethyl ether/hexane (1:2) and drying in vacuo afforded the isolation of the title compound as a light yellow solid: yield 2.63 g (57%); mp: 100–103 °C; ¹H NMR (DMSO-*d*₆, 400 MHz) δ /ppm: 9.08 (s, 1H, Ar–OH), 8.54 (d, 1H, Py–H), 7.56 (td, 1H, Py–H), 7.38 (d, 1H, Py–H), 7.25 (t, 1H, Py–H), 6.57 (d, 1H, Ar–H), 6.38 (dd, 1H, Ar–H), 5.47 (t, 1H, CH₂–NH), 4.39 (d, 2H, CH₂–NH), 1.12 (s, 9H, CH₃); ¹³C NMR (DMSO-*d*₆, 400 MHz) δ /ppm: 159.96, 149.16, 142.49, 142.07, 136.98, 135.74, 122.41, 121.99, 113.16, 49.04, 31.89. The single crystal used for X-ray diffraction analysis was obtained through the layering method, where a small amount of the product was dissolved in CH₂Cl₂ and layered with hexane and left at room temperature for four days.

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Abstract

C₁₆H₂₀N₂O, monoclinic, $P2_1/c$ (no. 14), $a = 9.7933(2)$ Å, $b = 17.5290(3)$ Å, $c = 17.1148(3)$ Å, $\beta = 101.242(1)^\circ$, $V = 2881.67(9)$ Å³, $Z = 8$, $R_{\text{gt}}(F) = 0.0402$, $wR_{\text{ref}}(F^2) = 0.1106$, $T = 150(2)$ K.

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The asymmetric unit of the title crystal structure is shown in the figure. Table 1 contains crystallographic data and Table 2 contains the list of the atoms including atomic coordinates and displacement parameters.

*Corresponding author: Muhammad D. Bala, School of Chemistry and Physics, University of KwaZulu-Natal, Westville Campus, Private Bag X54001, Durban 4000, South Africa, E-mail: bala@ukzn.ac.za.
<https://orcid.org/0000-0002-6302-6959>

Sipho Buthelezi, Halliru Ibrahim and Holger B. Friedrich, School of Chemistry and Physics, University of KwaZulu-Natal, Westville Campus, Private Bag X54001, Durban 4000, South Africa

Table 2: Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²).

Atom	<i>x</i>	<i>y</i>	<i>z</i>	<i>U</i> _{iso} */ <i>U</i> _{eq}
O1	0.01083 (11)	0.76479 (7)	0.55042 (7)	0.0410 (3)
H1	−0.068471	0.776783	0.558228	0.061*
N1	0.25461 (13)	0.43813 (7)	0.62008 (7)	0.0315 (3)
N2	0.14903 (15)	0.63258 (8)	0.55843 (8)	0.0420 (4)
H2	0.089983	0.647655	0.515684	0.050*
C1	0.20920 (17)	0.37824 (9)	0.65629 (10)	0.0388 (4)
H1A	0.270278	0.336129	0.669863	0.047*
C2	0.07918 (18)	0.37431 (9)	0.67492 (10)	0.0406 (4)
H2A	0.050658	0.330342	0.699961	0.049*
C3	−0.00866 (17)	0.43567 (9)	0.65638 (10)	0.0407 (4)
H3	−0.098479	0.435340	0.669587	0.049*
C4	0.03538 (17)	0.49760 (9)	0.61839 (10)	0.0382 (4)
H4	−0.024073	0.540383	0.604831	0.046*
C5	0.16757 (15)	0.49700 (8)	0.60006 (9)	0.0300 (3)
C6	0.22218 (17)	0.56163 (9)	0.55603 (10)	0.0362 (4)
H6A	0.321819	0.569701	0.579406	0.043*
H6B	0.215659	0.546465	0.499700	0.043*
C7	0.16888 (15)	0.67771 (8)	0.62594 (9)	0.0314 (3)
C8	0.09579 (15)	0.74693 (9)	0.62191 (9)	0.0319 (3)
C9	0.11624 (17)	0.79382 (9)	0.68732 (10)	0.0387 (4)
H9	0.068952	0.841366	0.684326	0.046*
C10	0.20493 (17)	0.77316 (9)	0.75804 (10)	0.0379 (4)
H10	0.216736	0.806702	0.802446	0.045*
C11	0.27612 (15)	0.70450 (9)	0.76462 (9)	0.0323 (3)
C12	0.25653 (15)	0.65738 (8)	0.69747 (9)	0.0326 (3)
H12	0.304362	0.610000	0.700557	0.039*
C13	0.51288 (18)	0.72856 (12)	0.84610 (13)	0.0563 (5)
H13A	0.554950	0.715393	0.800404	0.084*
H13B	0.577900	0.716024	0.895576	0.084*
H13C	0.492110	0.783280	0.845018	0.084*
C14	0.3169 (2)	0.70268 (13)	0.91527 (11)	0.0600 (5)
H14A	0.302259	0.757897	0.917310	0.090*
H14B	0.381652	0.686370	0.963466	0.090*
H14C	0.227732	0.676297	0.912024	0.090*
C15	0.4137 (2)	0.59804 (10)	0.84570 (12)	0.0530 (5)
H15A	0.327645	0.568031	0.838046	0.079*
H15B	0.471170	0.586084	0.897796	0.079*
H15C	0.465105	0.585532	0.803677	0.079*
C16	0.37781 (17)	0.68314 (10)	0.84190 (10)	0.0391 (4)
O2	0.51267 (10)	0.45625 (6)	0.58823 (6)	0.0317 (2)
H2B	0.433405	0.448696	0.598625	0.048*
N3	0.74829 (13)	0.79088 (7)	0.58469 (7)	0.0314 (3)
N4	0.64815 (15)	0.58821 (7)	0.57139 (8)	0.0385 (3)
H4A	0.588425	0.566971	0.532379	0.046*
C17	0.70414 (18)	0.85807 (9)	0.60786 (10)	0.0386 (4)
H17	0.761755	0.901513	0.606810	0.046*
C18	0.58012 (18)	0.86768 (10)	0.63306 (10)	0.0393 (4)
H18	0.552537	0.916480	0.648510	0.047*
C19	0.49703 (17)	0.80457 (10)	0.63528 (10)	0.0385 (4)
H19	0.411146	0.808910	0.652859	0.046*
C20	0.54064 (16)	0.73503 (9)	0.61156 (9)	0.0352 (4)
H20	0.484966	0.690820	0.612710	0.042*
C21	0.66606 (15)	0.73005 (8)	0.58605 (8)	0.0270 (3)
C22	0.71764 (18)	0.65680 (8)	0.55486 (9)	0.0338 (4)

Table 2: (continued)

Atom	<i>x</i>	<i>y</i>	<i>z</i>	<i>U</i> _{iso} */ <i>U</i> _{eq}
H22A	0.708246	0.661482	0.496407	0.041*
H22B	0.818067	0.651432	0.577863	0.041*
C23	0.67035 (15)	0.55400 (8)	0.64535 (8)	0.0272 (3)
C24	0.59976 (14)	0.48582 (8)	0.65453 (8)	0.0264 (3)
C25	0.62153 (16)	0.45004 (9)	0.72707 (9)	0.0324 (3)
H25	0.573853	0.403798	0.732790	0.039*
C26	0.71207 (16)	0.48020 (9)	0.79239 (9)	0.0330 (4)
H26	0.725633	0.454319	0.842081	0.040*
C27	0.78302 (15)	0.54782 (8)	0.78584 (9)	0.0276 (3)
C28	0.76030 (15)	0.58375 (8)	0.71167 (9)	0.0279 (3)
H28	0.807767	0.630108	0.706142	0.034*
C29	0.8365 (2)	0.56973 (11)	0.93454 (10)	0.0492 (5)
H29A	0.747097	0.596075	0.930524	0.074*
H29B	0.904474	0.591645	0.978435	0.074*
H29C	0.824339	0.515363	0.944664	0.074*
C30	0.91793 (19)	0.66420 (9)	0.84696 (11)	0.0442 (4)
H30A	0.965985	0.671113	0.802306	0.066*
H30B	0.976728	0.683451	0.895956	0.066*
H30C	0.829835	0.692394	0.836408	0.066*
C31	1.02508 (18)	0.53460 (11)	0.86177 (11)	0.0489 (5)
H31A	1.007664	0.480165	0.868505	0.073*
H31B	1.093812	0.552898	0.907381	0.073*
H31C	1.060811	0.542242	0.812698	0.073*
C32	0.88861 (16)	0.57926 (9)	0.85665 (9)	0.0320 (3)

Experimental details

All hydrogen atoms were placed in idealized positions and refined in riding models with U_{iso} assigned the values of 1.2 times those of their parent atoms, and the distances of C–H were constrained to 0.93 Å for all the aromatic H atoms, 0.96 Å for methyl hydrogens and 0.98 Å for methine hydrogen.

Comment

The title compound was prepared as part of an ongoing study involving the application of chelating ligands [5] and their transition metal complexes [6]. Pincer tridentate ligands are important in coordination chemistry as they provide *mer*-coordination mode to the metal, which improves the thermal stability of the complex and stabilizes its various oxidation & coordination modes, especially during molecular catalysis [7, 8]. Complexes bearing tridentate ligands have been applied as anti-cancer [9, 10] and antimicrobial agents [11]. They have also been utilized in numerous catalytic applications, including mild alkane [12–14] and alcohol [15] oxidation,

double bond cleavage [16], transfer hydrogenation [17] and polymerization [18].

The title compound crystallized in the centrosymmetric $P2_1/c$ space group with two molecules in the asymmetric unit cell. There are two symmetry elements along the b-direction, a 2-fold screw axis at 0, y, 1/4 with screw component [0, 1/2, 0] and a glide plane c perpendicular to the b-direction with glide component [0, 0, 1/2]. Hence, the structure of the compound is analogous to that reported by Chaudhuri et al. [19], while the arrangement of the asymmetric unit is similar to the structure reported by Zamisa et al. [20]. Strong intermolecular H-bonding connects molecules of the title compound. Notably, each phenolic group interacts with the neighbouring pyridyl moiety through $O(1)-H\cdots N(3)$ (1.95 Å) and $O(2)-H\cdots N(1)$ (1.87 Å) H-bonds. This is further strengthened by slightly weaker intramolecular H-bonds [$N(4)-H\cdots O(2)$ (2.15 Å)] involving the *N*-methylamine and the phenolic OH groups. Similar molecular interactions were reported for related compounds bearing donor O and N heteroatoms [19]. Also, the *N*-methylene linker facilitated the almost perpendicular (85.85°) dissection of the planes of the pyridyl [atoms N(3), C(17)–C(21)] and phenolic [atoms O(2), C(23)–C(29)] moieties, hence reducing intramolecular steric repulsive forces within each molecule [5]. The tertiary butyl substituent, on the other hand, increases the solubility of the title compound in a variety of organic solvents, which is crucial for its application in many of the aforementioned fields [21, 22].

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References

1. Bruker. APEXII; Bruker AXS Inc: Madison, WI, USA, 2009.
2. Sheldrick G. M. *SHELXTL* – integrated space-group and crystal-structure determination. *Acta Crystallogr.* 2015, *A71*, 3–8.
3. Sheldrick G. M. Crystal structure refinement with SHELXL. *Acta Crystallogr.* 2015, *C71*, 3–8.
4. Dolomanov O. V., Bourhis L. J., Gildea R. J., Howard J. A. K., Puschmann H. OLEX2: a complete structure solution, refinement and analysis program. *J. Appl. Crystallogr.* 2009, *42*, 339–341.
5. Nyalungu N., Alapour S., Friedrich H. B., Bala M. D. Crystal structure of (2,7-dihexyl-9,9-dimethyl-9*H*-xanthene-4,5-diyl) bis(diphenylphosphane), $C_{51}H_{56}OP_2$. *Z. Kristallogr. NCS* 2020, *235*, 461–463.
6. Gichumbi J., Friedrich H. B., Omondi B. Comparative structural description of five arene ruthenium(II) complexes of *N,N*-bidentate Schiff base ligands to related complexes from literature. *Transit. Met. Chem.* 2020, in press; <https://doi.org/10.1007/s11243-020-00417-5>.
7. Badaj A. C., Lavoie G. G. Synthesis and structural characterization of nickel(II) complexes with imino-*N*-heterocyclic carbene heteroditopic ligands. *Organometallics* 2012, *31*, 1103–1111.
8. Ibrahim H., Bala M. D. Air stable pincer (CNC) *N*-heterocyclic carbene–cobalt complexes and their application as catalysts for C–N coupling reactions. *J. Organomet. Chem.* 2015, *794*, 301–310.
9. Gichumbi J. M., Friedrich H. B., Omondi B., Lazarus G. G., Singh M., Chenia H. Y. Synthesis, characterization, anticancer and antimicrobial study of arene ruthenium(II) complexes with 1,2,4-triazole ligands containing an alpha-diimine moiety. *Z. Naturforsch. B: Chem. Sci.* 2018, *73*, 167–178.
10. Wehbe M., Lo C., Leung A. W. Y., Dragowska W. H., Ryan G. M., Bally M. B. Copper(II) complexes of bidentate ligands exhibit potent anticancer activity regardless of platinum sensitivity status. *Invest. N. Drugs* 2017, *35*, 682–690.
11. Gichumbi J. M., Friedrich H. B., Omondi B. O. Synthesis, characterization and antimicrobial studies of half-sandwich η^6 -toluene ruthenium complexes with *N,N'*-bidentate ligands. *J. Coord. Chem.* 2020, *73*, 1833–1847.
12. Naicker D., Alapour S., Friedrich H. B. The effects of metals and ligands on the oxidation of *n*-octane using iridium and rhodium “PNP” aminodiphosphine complexes. *J. Chem. Res.* 2020, <https://doi.org/10.1177/1747519820967245>, In press.
13. Soobramony L., Bala M. D., Friedrich H. B. Coordination chemistry of Co complexes containing tridentate SNS ligands and their application as catalysts for the oxidation of *n*-octane. *Dalton Trans.* 2014, *43*, 15968–15978.
14. Gunanathan C., Milstein D. Bond activation and catalysis by ruthenium pincer complexes. *Chem. Rev.* 2014, *114*, 12024–12087.
15. Marimuthu T., Alapour S., Friedrich H. B. Microwave-assisted oxidation reaction of alcohols with sensitive functional groups to aldehydes using ruthenium diphosphorus complexes. *ARKIVOC* 2020, *2020*, 120–135.
16. Gichumbi J. M., Omondi B., Friedrich H. B. Synthesis and characterization of water soluble arene-ruthenium complexes and their application in biphasic olefin oxidation. *J. Coord. Chem.* 2019, *72*, 135–147.
17. Abubakar S., Bala M. D. Transfer hydrogenation of ketones catalyzed by symmetric imino-*N*-heterocyclic carbene Co(III) complexes. *ACS Omega* 2020, *5*, 2670–2679.
18. Li A., Ma H., Huang J. Highly thermally stable eight-coordinate dichloride zirconium complexes supported by tridentate [ONN] ligands: syntheses, characterization, and ethylene polymerization behaviour. *Organometallics* 2013, *32*, 7460–7469.
19. Khanra S., Kuepper K., Weyhermüller T., Prinz M., Raekers M., Voget S., Postnikov A. V., de Groot F. M. F., George S. J., Coldea M., Neumann M., Chaudhuri P. Star-shaped molecule of $Mn_4^II O_6$ core with an $St = 10$ high-spin state. a theoretical and experimental study with XPS, XMCD, and other magnetic methods. *Inorg. Chem.* 2008, *47*, 4605–4617.

20. Yerima I. B., Zamisa S. J., Bala M. D. Crystal structure of 4-*tert*-butyl-1-(2, 6-dimethylphenyl)-1*H*-1,2,3-triazole, C₁₄H₁₉N₃. *Z. Kristallogr. NCS* 2019, 234, 625–627.
21. Kastler M., Pisula W., Wasserfallen D., Pakula T., Müllen K. Influence of alkyl substituents on the solution-and surface-organization of hexa-peri-hexabenzocoronenes. *J. Am. Chem. Soc.* 2005, 127, 4286–4296.
22. Bronger R. P., Kamer P. C., van Leeuwen P. W. Influence of the bite angle on the hydroformylation of internal olefins to linear aldehydes. *Organometallics* 2003, 22, 5358–5369.